Making Transit Card Keychains:

RFID and NFC Technology

Transit Card Keychains

- Today, we're going to talk about RFID and NFC
  - Radio-frequency identification
  - Near field communication

How you seen these before?

- Tap to pay

How many of you have used this?

- Transit card

How do you open this door?

- Door opened by security fob

What do these do?

- Theft tags

Other Examples

- Library cards
- Passports

- Tags!

Goals of Session

- Make NFC stuff

NFC

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A Look Inside a Transit Card

Making an NFC Keychain

More Things to Do with NFC

- How does NFC work?
  - If I asked you to build a card
    - for opening doors
    - or paying for things,
  - how would you do it?

- Has a chip for your data and encryption
- RFID uses no batteries
  - Devices can be cheap, small, long-lasting
  - Wireless power
- Only support nearby communication
  - Data transmission hard to do at a distance
  - Hard to snoop data and track people

NFC

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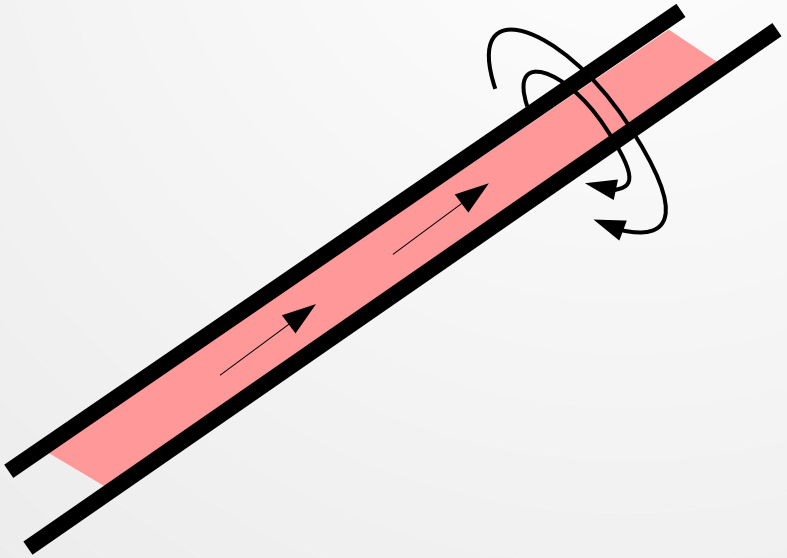
More Things to Do with NFC

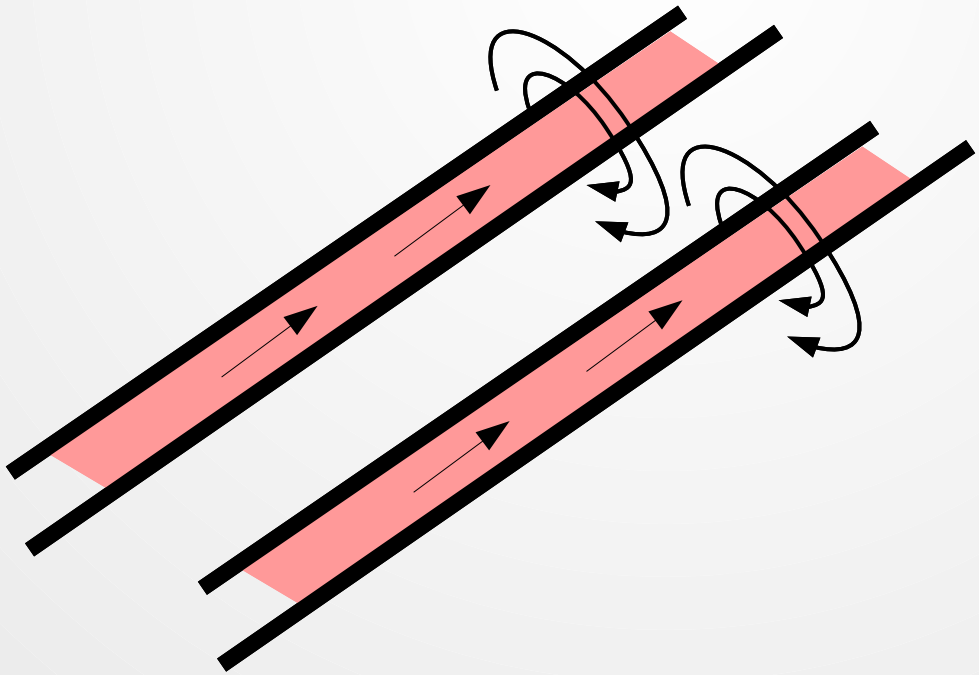
- Underlying physics magic used for wireless power and communication:
  - Magnetic Induction

Electromagnets

- When electricity flows through a wire, it makes a weak magnetic field around it



- Can increase strength of magnetic field
  - Use more electricity
  - Use more than one wire (so fields overlap)
    - Use a coil



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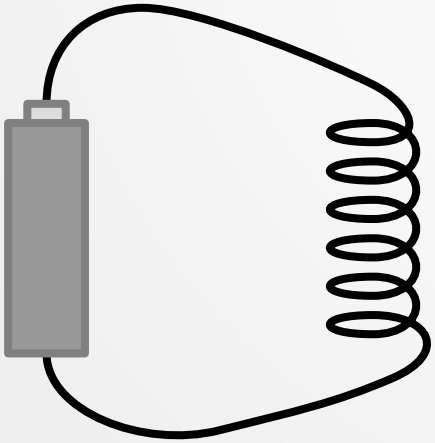

- Electromagnetic field demonstration
  - Magnets can pick up metal
  - Coil of wire around a nail
    - Not magnetic
  - Attach coil to a battery
    - It can pick up metal
    - (Danger: wires and battery can overheat!)
  - Basis for electric motors
    - Vacuum, cars, washing machine, etc.

https://youtu.be/bDA-39izAwA
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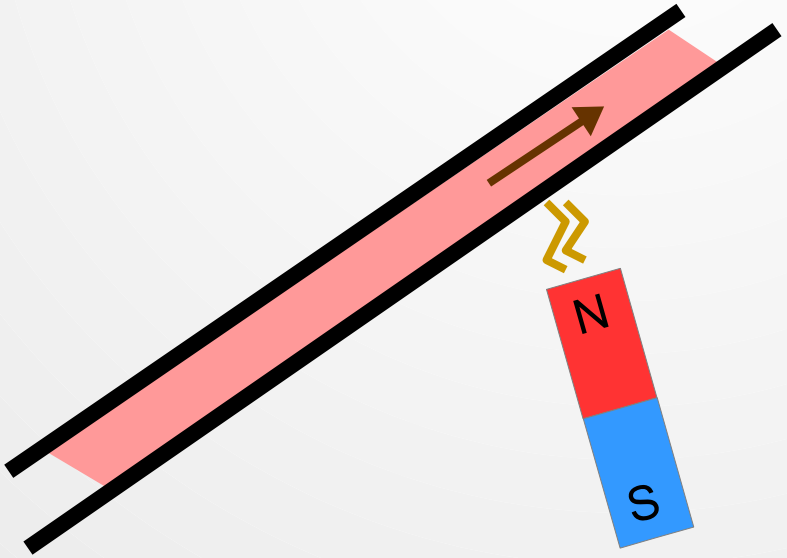
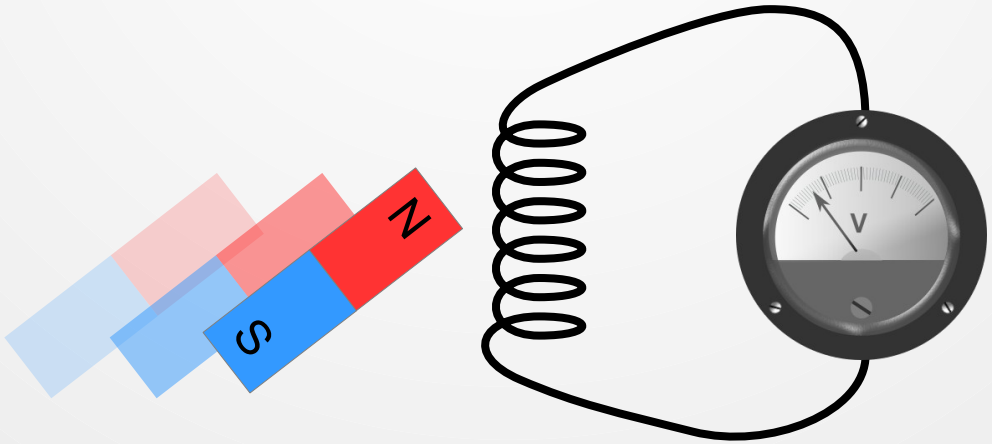
Magnetic induction

- It works the opposite way too
  - Magnetic fields can create electricity
  - But it has to be a moving magnetic field



Magnetic induction

- Magnetic induction demonstration
  - Hook up coil to a voltmeter
  - Move a strong magnet near it
  - See electricity flowing
    - Magnets and wires don't have to touch but should be close
    - More coils and faster movement = more voltage



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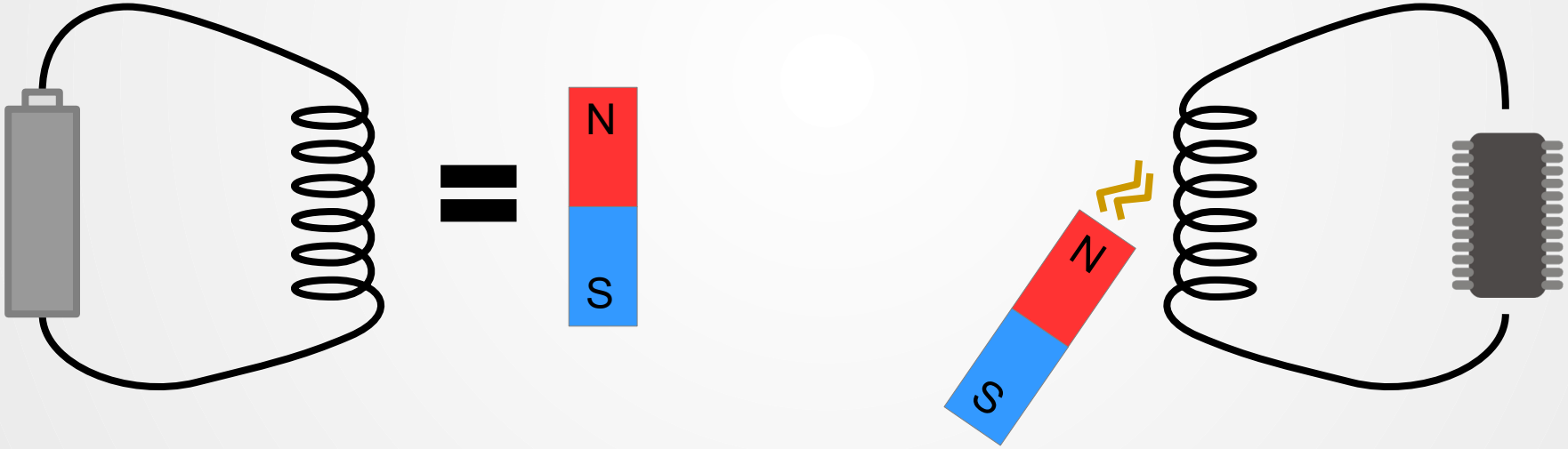
Magnetic induction

- Magnetic induction demonstration
  - Basis for electric generators
    - Most electricity generated this way
      - Except batteries and solar

Wireless Power

- Can create a magnet using electricity
- Moving magnets can create electricity



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- Can transfer power wirelessly
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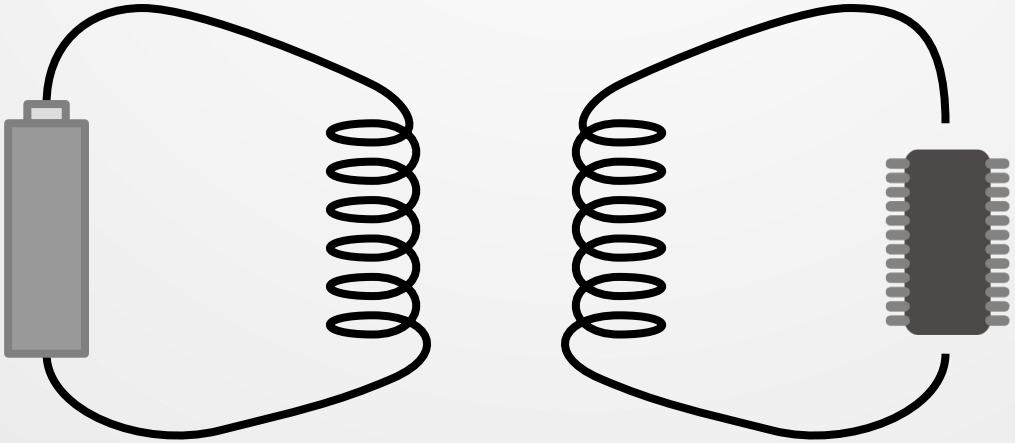

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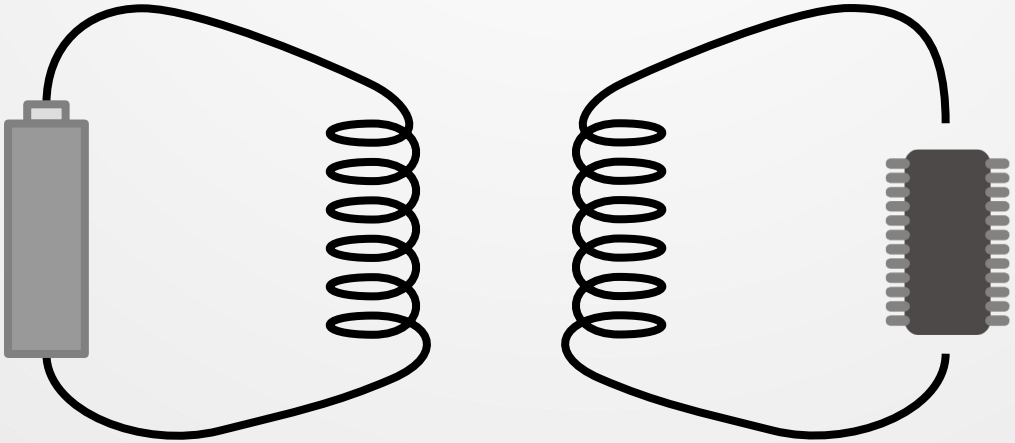

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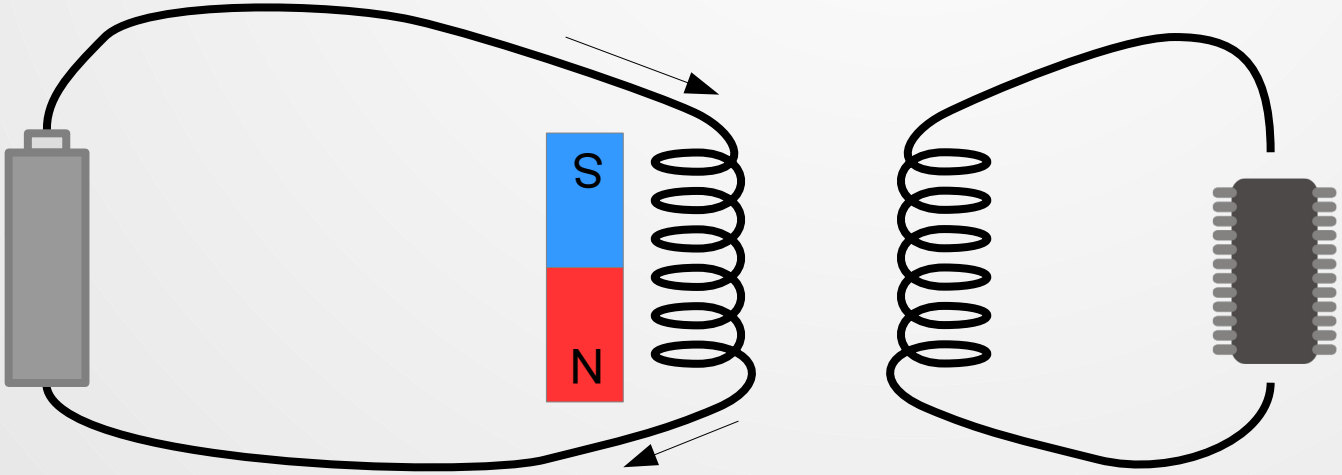
  - Easier to constantly reverse the flow of electricity
    - Can do this millions of times per second
    - Much faster than spinning



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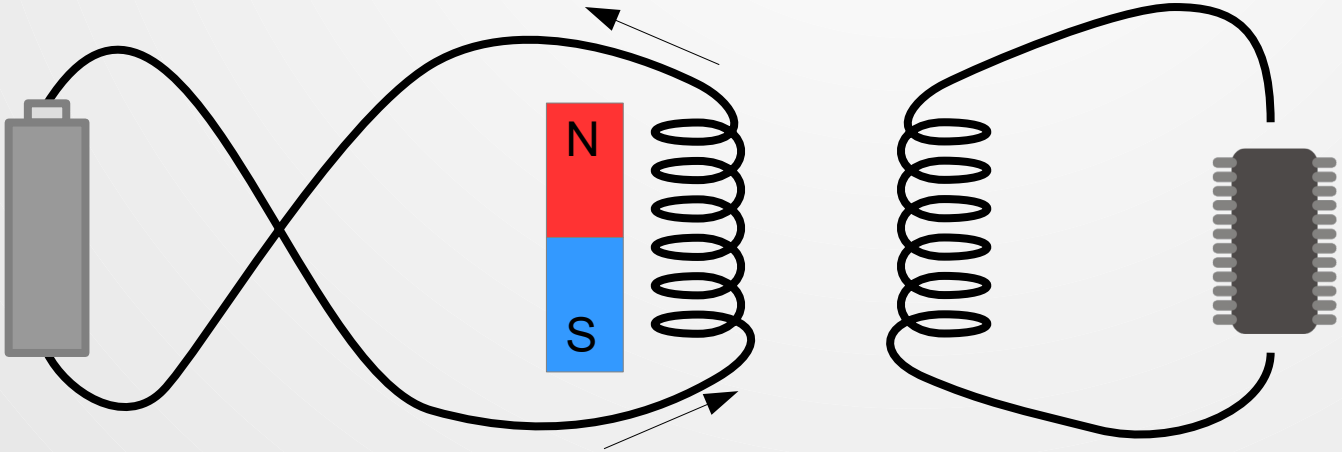

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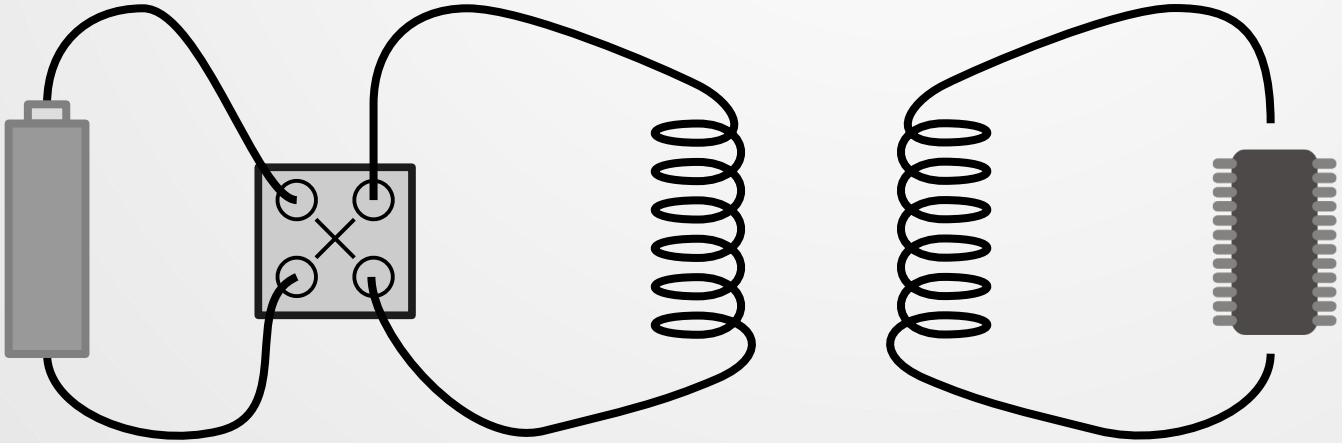

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  - When one coil is connected to battery
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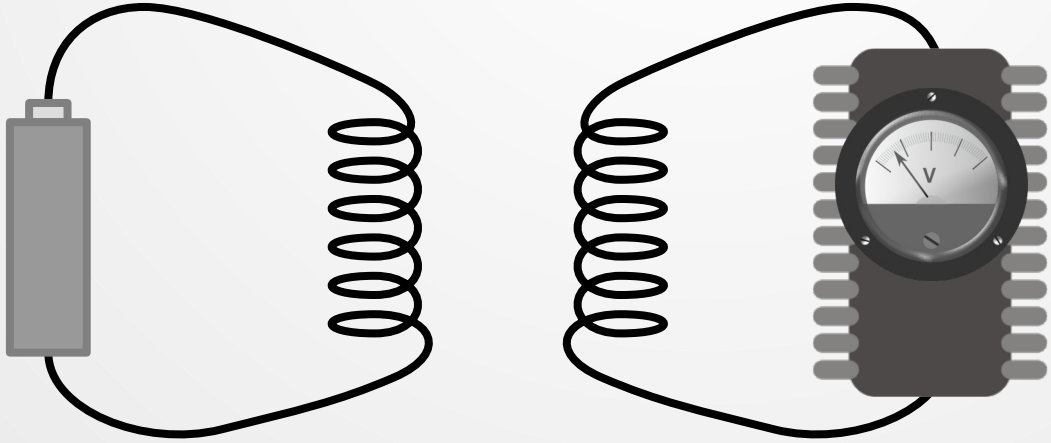

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Wireless Power

- Wireless power demonstration
  - Voltage detected when connection is changed
    - Nothing happens when current is entirely on or off

https://youtu.be/8PYmoTfDy8g

NFC

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A Look Inside a Transit Card

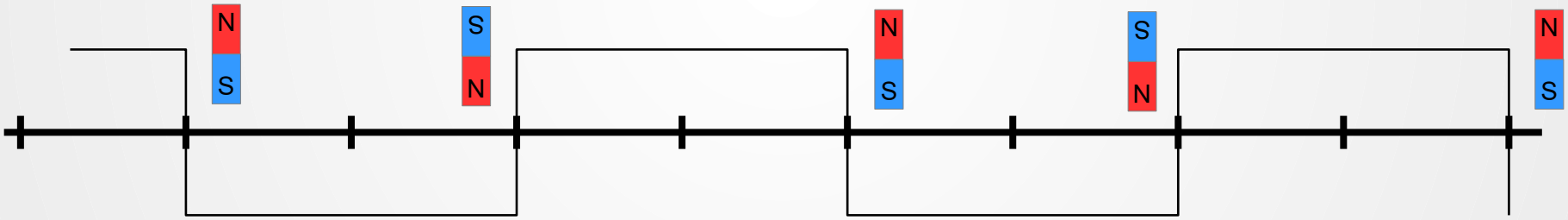
Making an NFC Keychain

More Things to Do with NFC

What's Inside NFC?

- Magnetic induction in NFC
- Coil on device (e.g. transit card)
- Coil on reader
- Flip electricity direction repeatedly, flip magnetic poles, induce electricity in device coil

- Transmit using magnetic induction
  - Magnetic polarity (and electricity direction flow) keeps flipping
    - Add some jitter to when the flips occur



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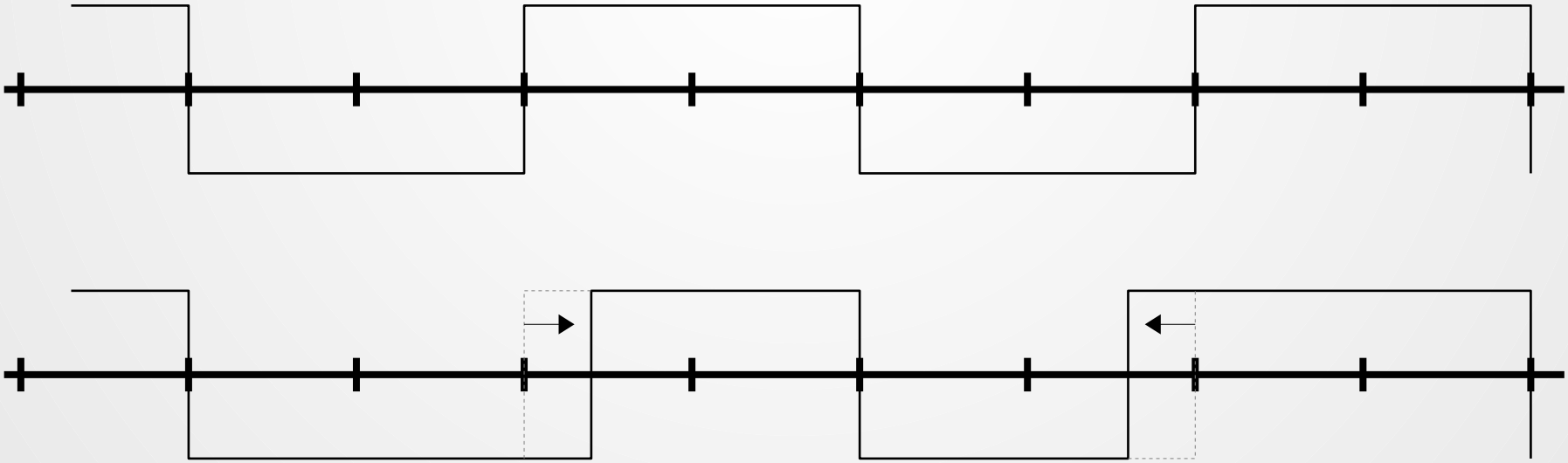
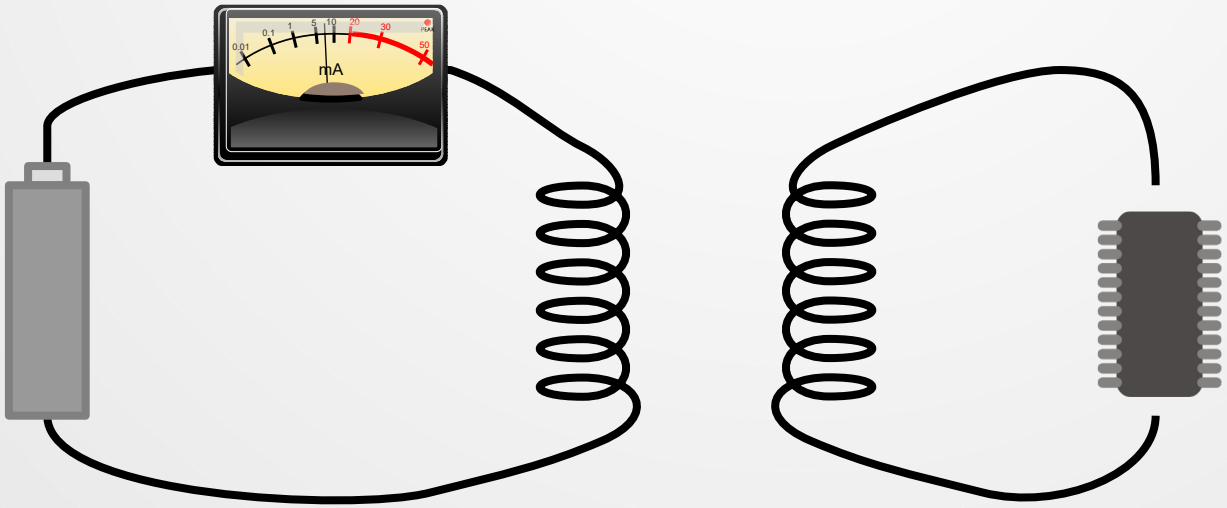


- Receive using magnetic induction
  - As the receiving device uses more power
    - Sender uses more energy to power the magnetic field
  - Receiving device can adjust its power usage
    - Sender can detect this
    - Use this as a signal



How Does It Work?

- Where is the magnetic coil?
- What happens if you walk around the gates instead of between them?

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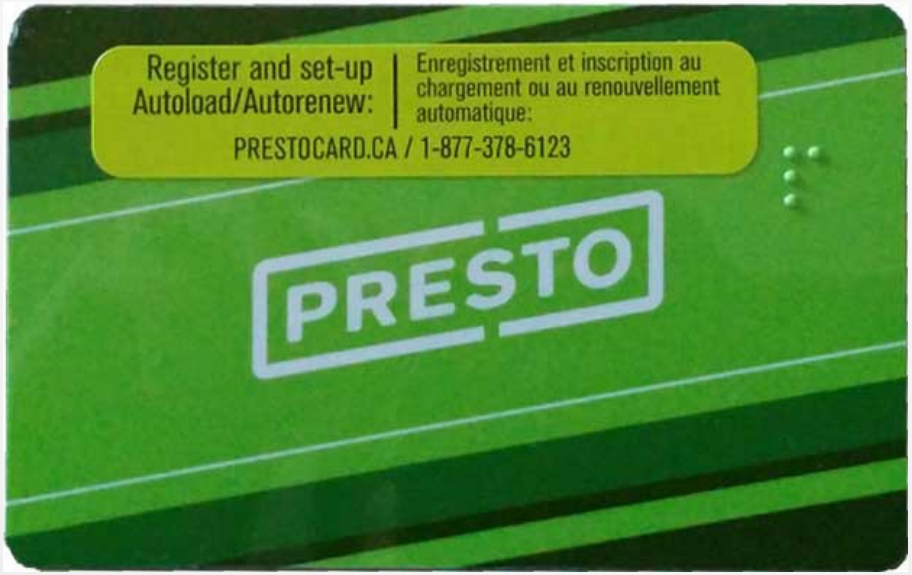
More Things to Do with NFC

- Now that we know how NFC works, can we do anything with it?

- We can customize and personalize our NFC devices to fit our own needs

- PRESTO transit card
- Many NFC devices are in the shape of cards
- Sort of ugly and blah

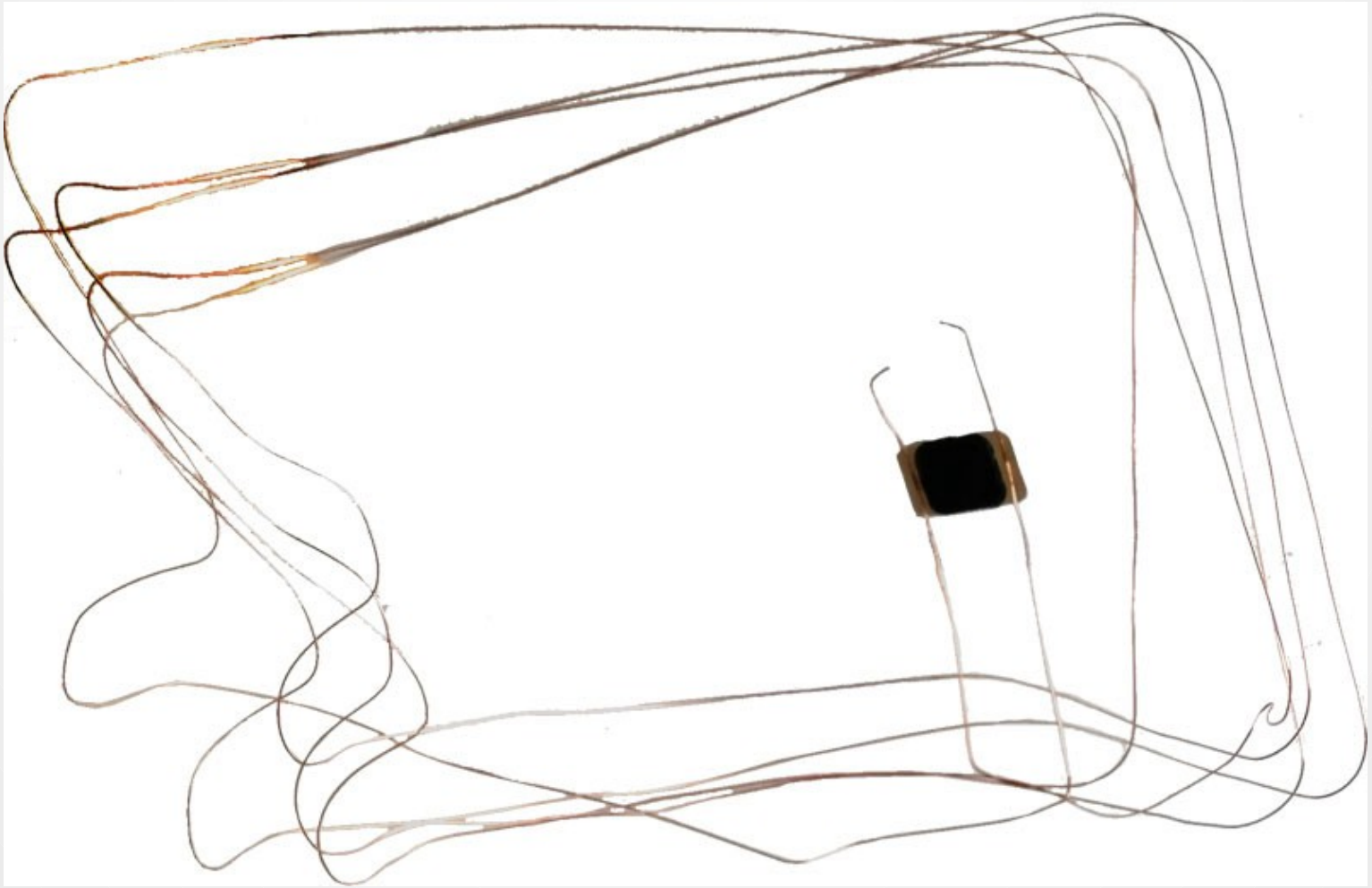


- PRESTO card made of plastic
  - Can melt it with nail polish remover

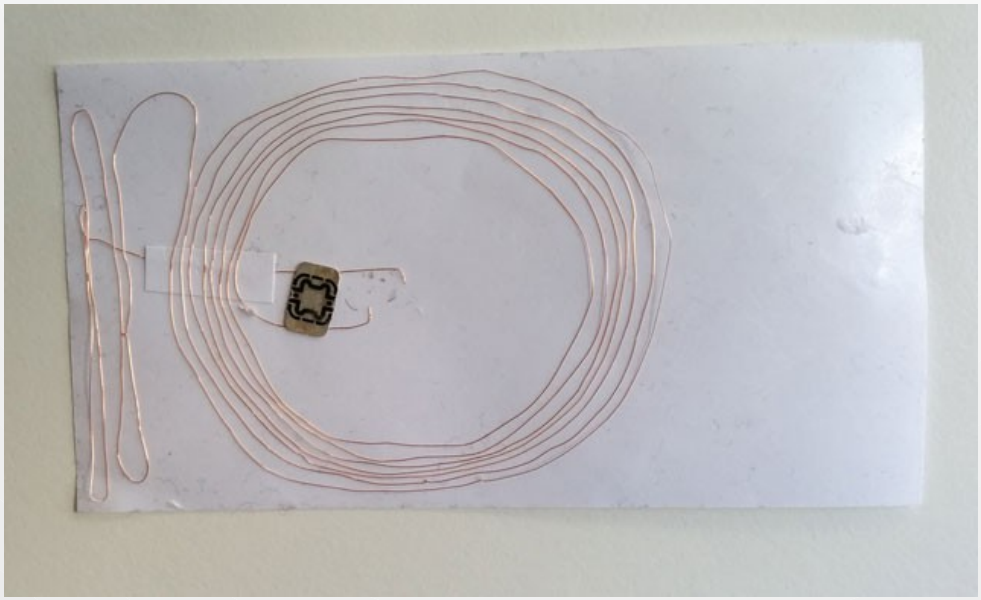
- Front and back covers will soften
  - Can peel them off

- Chip and coil around the edge of card
  - Can peel the two layers around it

- Inside the PRESTO card

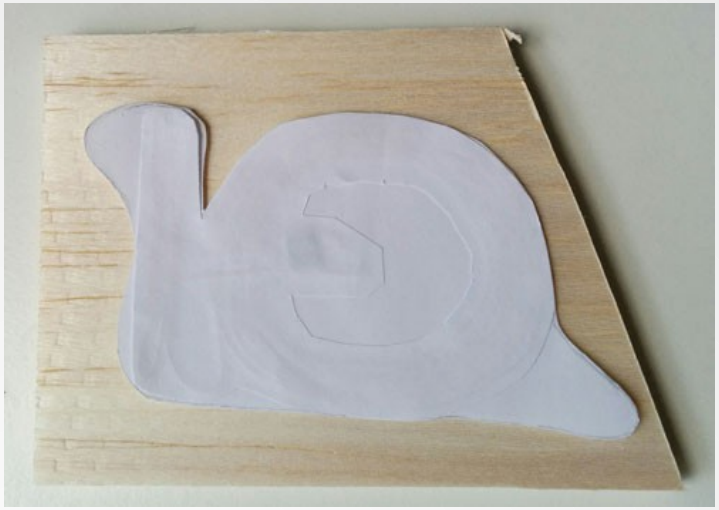


- Want a different shape?
  - Reshape the induction coil
    - Still has to be multiple loops
    - Can be a ring, bracelet, amulet
    - Weirder shapes are possible too

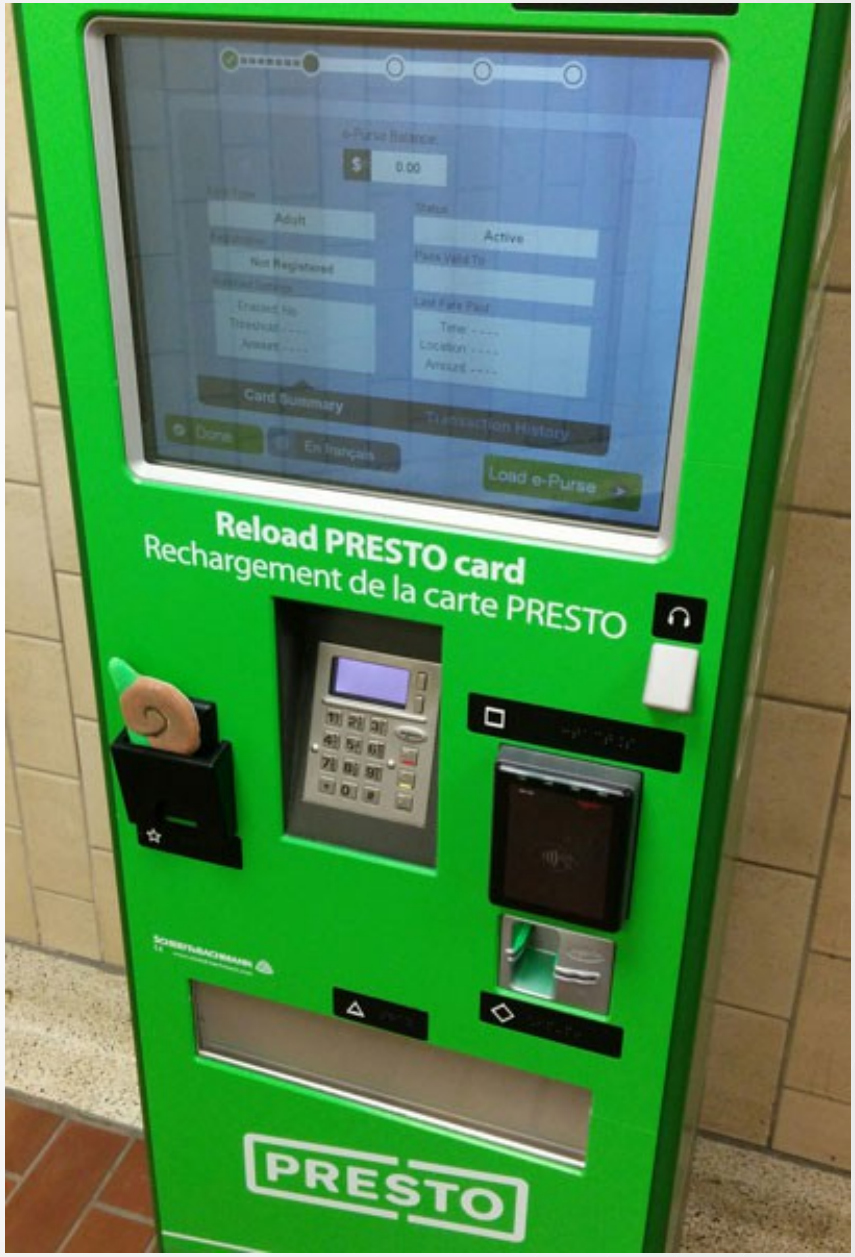


- Cut out shape

- Make it 3d



- PRESTO snail in use



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More Things to Do with NFC

- Making your own NFC stuff
- Transit cards
  - Expensive, time-consuming
- Instead we'll use generic NFC stickers
  - Can order rolls of “NFC stickers” from Ebay
  - Hold it up to the light to see the coil and chip

Unleash Your Creativity

- We've got
  - Felt, foam sheets, construction paper
  - Scissors, hole punch
  - Markers, crayons
  - Glue, glue
  - Extra-large stickers
  - Clasps, carabiners, safety pins

- Keychains
  - Punch a hole
  - Attach sticker to flat bottom part
  - Add keys

- Pendant
  - Add two holes for string
  - Attach sticker to back of it

- Stickers
  - For binders, lockers, pencil cases
  - Put NFC sticker on back of sticker

- Out of ideas?
  - Cut out one of the shapes from the template
    - Template also shows how to program your NFC tag

- Don't cut or put holes in NFC stickers
- Leave NFC sticker on outside
  - Easier to transfer power to it

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More Things to Do with NFC

Extra: Programming your NFC tag

- NFC chip is programmable
- Most NFC chips let you store some data there
  - On the order of 100-1000 bytes of data
- On Android phones, you can use app NXP TagInfo to read tags, NXP Tag Writer to write tags

- NDEF
  - Standardized data that you can write to tags
  - When Android phones read those tags, you can trigger some simple actions
    - Show some text
    - Make a phone call
    - Open a web page
  - Demo of tag writing

- Make a tag that goes to your home page
  - Show your resume?
  - Shows your social networks?
- Make a tag that has your contact information
- Record your medical information there

- Other things?

Extra: Security

- Some types of attacks against NFC cards
  - Can you track someone remotely?
  - Can you read the data on their cards?
    - Is that a problem?
  - Can you copy someone's card?
    - Can you create a fake card and pretend it has more money on it?
  - Can you eavesdrop on communication?

Extra: TDMA, FDMA

- Wallet full of NFC tags—what happens?
- Don't want to “jam” the communication signal with all the tags talking at the same time
- NFC uses TDMA and FDMA
  - Discuss the theory

Making Transit Card Keychains:

RFID and NFC Technology

Transit Card Keychains

- Today, we're going to talk about RFID and NFC
  - Radio-frequency identification
  - Near field communication

- RFID is the general technology
- NFC is a standard for a specific type of RFID

How you seen these before?

- Tap to pay

3

- Ice breaker: ask them to put hands up if they've seen one of these before

How many of you have used this?

- Transit card

How do you open this door?

- Door opened by security fob

What do these do?

- Theft tags

Other Examples

- Library cards
- Passports
- Tags!

- Get kids to try tapping their Android phones on a tag to get a special message

Goals of Session

- Make NFC stuff

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- Same technology as transit cards etc
- Due to cost, won't actually make a transit card keychain
- Will show you the steps needed to do it though

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More Things to Do with NFC

- How does NFC work?
  - If I asked you to build a card
    - for opening doors
    - or paying for things,
  - how would you do it?

10

- Factors to consider
  - Power (e.g. solar, batteries, wireless)
  - Size (batteries are heavy, big, brittle, expensive)
  - Cost
  - How to transmit data (lights? Radio?)
  - How to store data
  - Security

- Has a chip for your data and encryption
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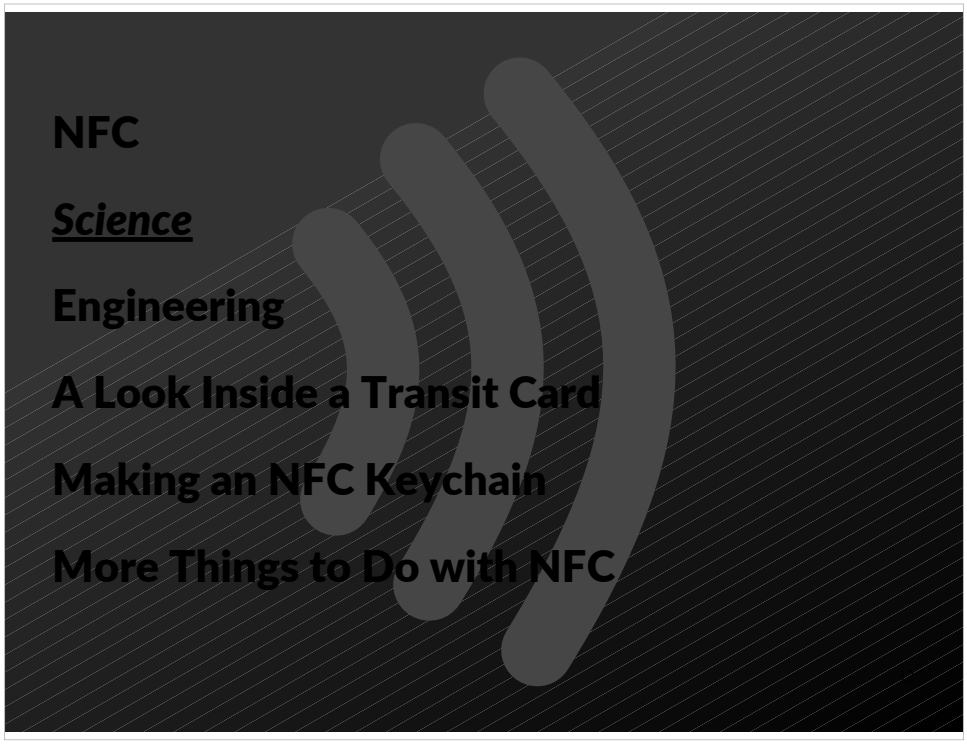
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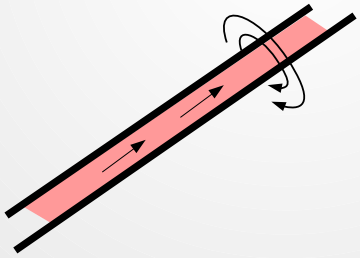

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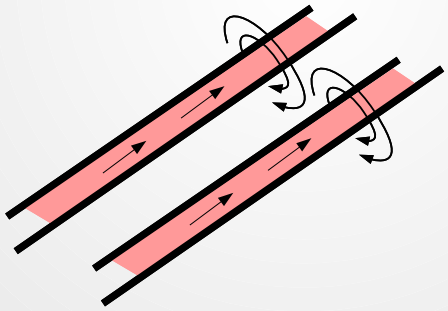

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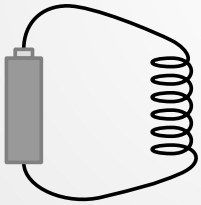

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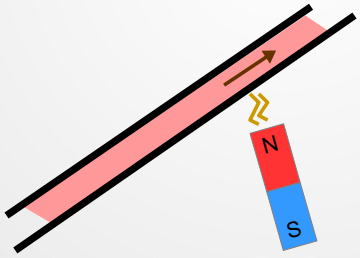

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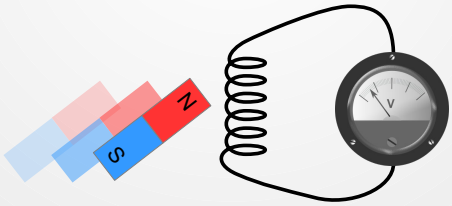

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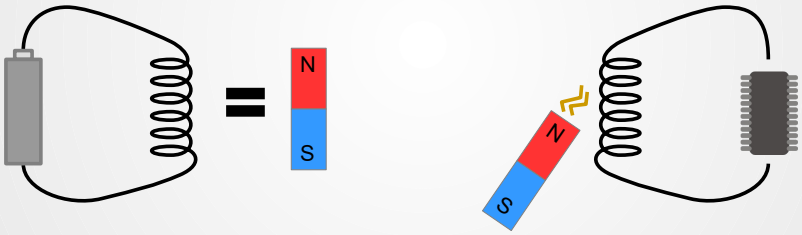

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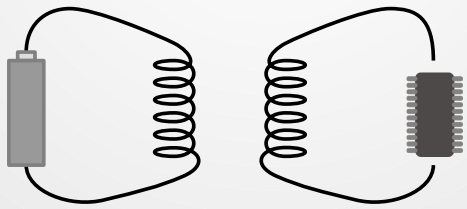

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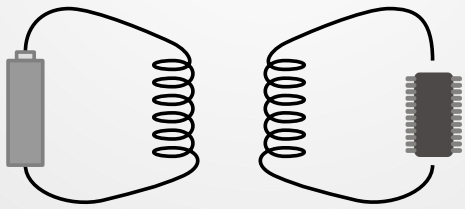

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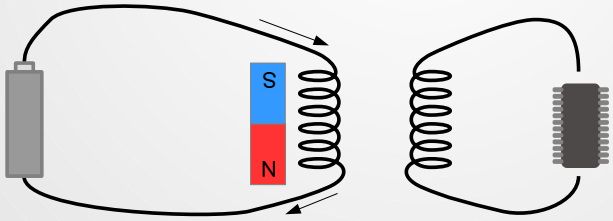

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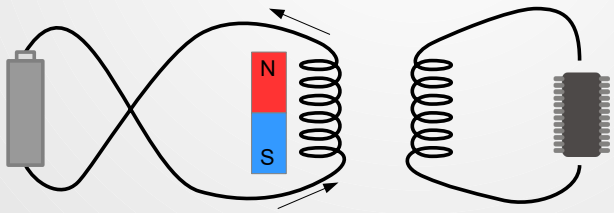

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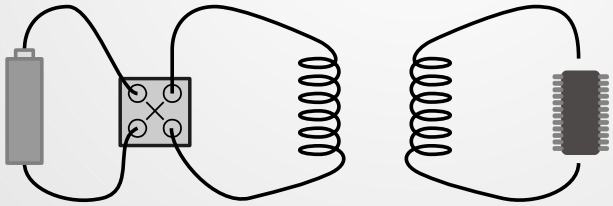

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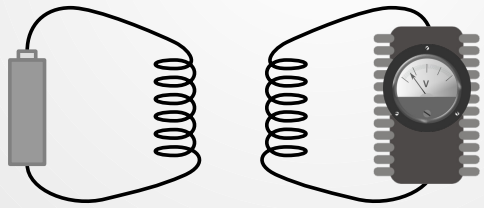
  - When one coil is connected to battery
    - Voltage detected in other coil



https://youtu.be/8PYmoTfDy8g

Wireless Power

- Wireless power demonstration
  - Voltage detected when connection is changed
    - Nothing happens when current is entirely on or off

https://youtu.be/8PYmoTfDy8g

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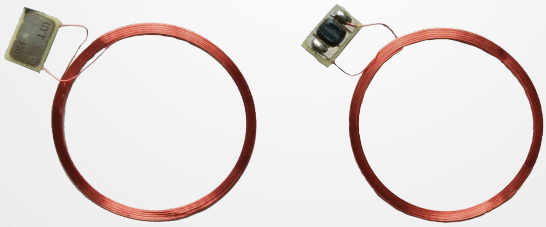
More Things to Do with NFC

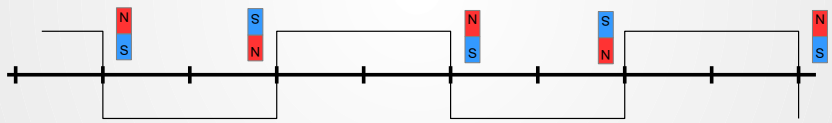
What's Inside NFC?

- Magnetic induction in NFC
- Coil on device (e.g. transit card)
- Coil on reader
- Flip electricity direction repeatedly, flip magnetic poles, induce electricity in device coil



- Show the inside of an NFC device

- Transmit using magnetic induction
  - Magnetic polarity (and electricity direction flow) keeps flipping
    - Add some jitter to when the flips occur



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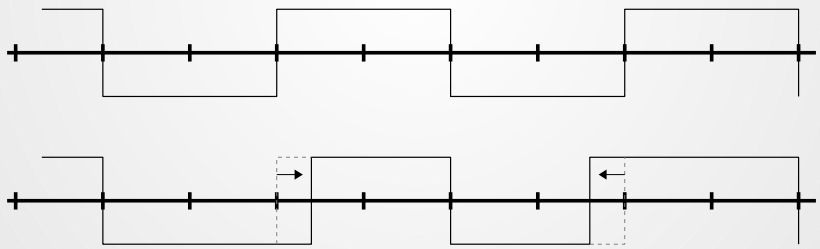
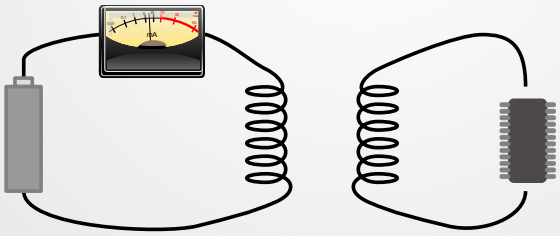


- Receive using magnetic induction
  - As the receiving device uses more power
    - Sender uses more energy to power the magnetic field
  - Receiving device can adjust its power usage
    - Sender can detect this
    - Use this as a signal



How Does It Work?

- Where is the magnetic coil?
- What happens if you walk around the gates instead of between them?

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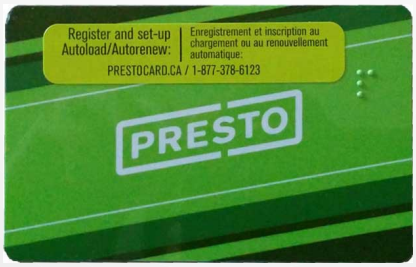
More Things to Do with NFC

- Now that we know how NFC works, can we do anything with it?
- We can customize and personalize our NFC devices to fit our own needs

- PRESTO transit card
- Many NFC devices are in the shape of cards
- Sort of ugly and blah



- PRESTO card made of plastic
  - Can melt it with nail polish remover

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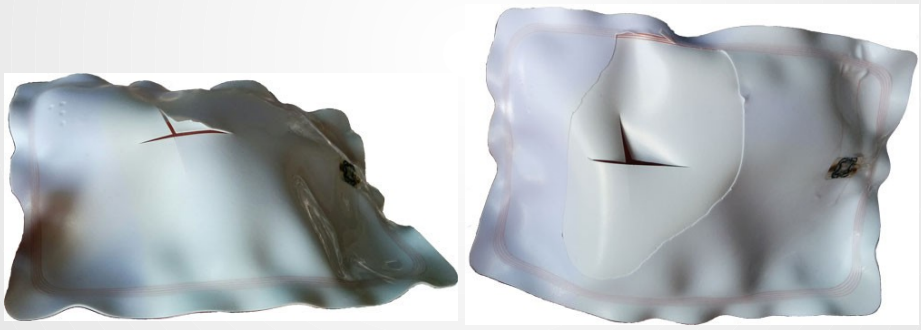
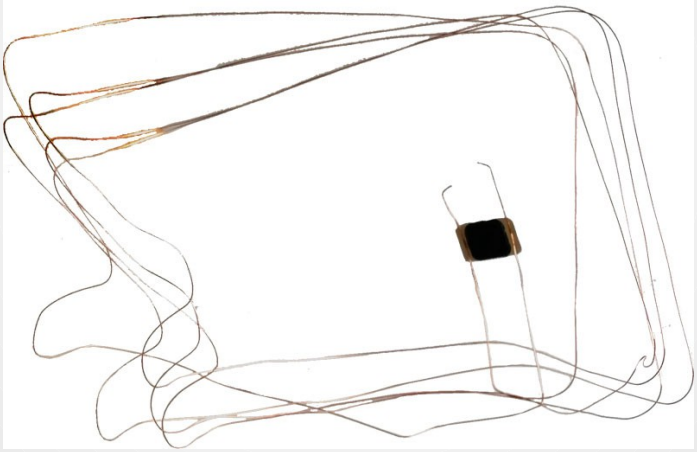
- Nail polish remover can dissolve lots of stuff
  - It might melt through plastic containers
  - We use a metal tray to hold everything
- Pour nail polish remover until it covers the card
- Let it sit for a few hours as it dissolves the plastic and softens it

- Front and back covers will soften
  - Can peel them off

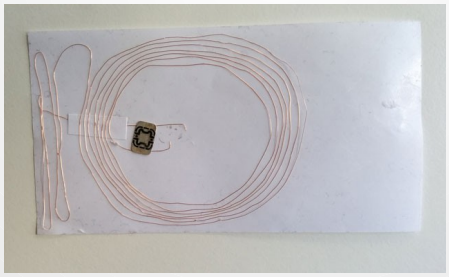
- Chip and coil around the edge of card
  - Can peel the two layers around it



- Inside the PRESTO card



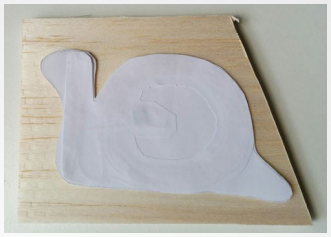
- Want a different shape?
  - Reshape the induction coil
    - Still has to be multiple loops
    - Can be a ring, bracelet, amulet
    - Weirder shapes are possible too



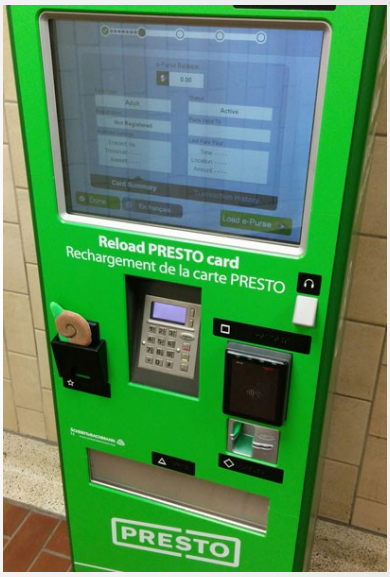
Use a big sticker to hold coil in place

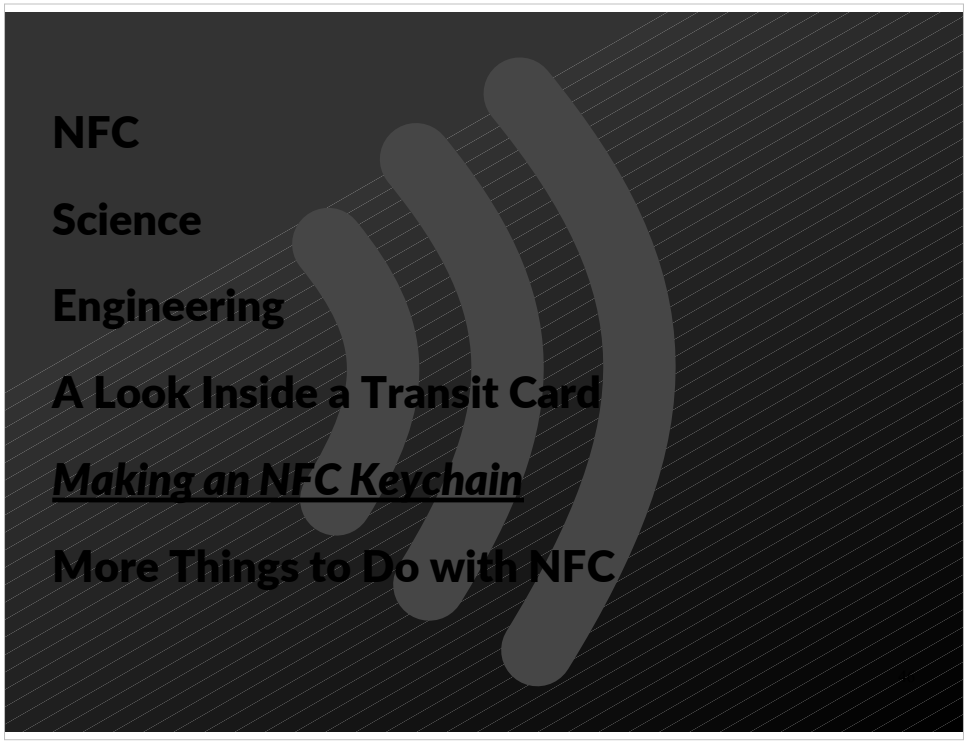
- Cut out shape

- Make it 3d



- PRESTO snail in use

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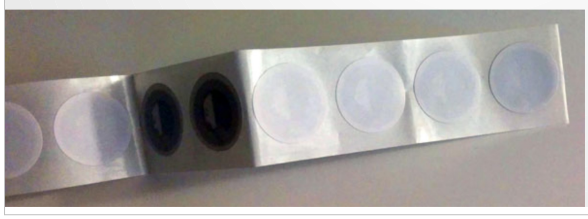
More Things to Do with NFC

- Making your own NFC stuff
- Transit cards
  - Expensive, time-consuming
- Instead we'll use generic NFC stickers
  - Can order rolls of “NFC stickers” from Ebay
  - Hold it up to the light to see the coil and chip



Unleash Your Creativity

- We've got
  - Felt, foam sheets, construction paper
  - Scissors, hole punch
  - Markers, crayons
  - Glue, glue
  - Extra-large stickers
  - Clasps, carabiners, safety pins

- Keychains
  - Punch a hole
  - Attach sticker to flat bottom part
  - Add keys

- Pendant
  - Add two holes for string
  - Attach sticker to back of it

- Stickers
  - For binders, lockers, pencil cases
  - Put NFC sticker on back of sticker

- Out of ideas?
  - Cut out one of the shapes from the template
    - Template also shows how to program your NFC tag
- Don't cut or put holes in NFC stickers
- Leave NFC sticker on outside
  - Easier to transfer power to it

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More Things to Do with NFC

Extra: Programming your NFC tag

- NFC chip is programmable
- Most NFC chips let you store some data there
  - On the order of 100-1000 bytes of data
- On Android phones, you can use app NXP TagInfo to read tags, NXP Tag Writer to write tags

- NDEF
  - Standardized data that you can write to tags
  - When Android phones read those tags, you can trigger some simple actions
    - Show some text
    - Make a phone call
    - Open a web page
  - Demo of tag writing

- Make a tag that goes to your home page
  - Show your resume?
  - Shows your social networks?
- Make a tag that has your contact information
- Record your medical information there

- Other things?

Extra: Security

- Some types of attacks against NFC cards
  - Can you track someone remotely?
  - Can you read the data on their cards?
    - Is that a problem?
  - Can you copy someone's card?
    - Can you create a fake card and pretend it has more money on it?
  - Can you eavesdrop on communication?

Extra: TDMA, FDMA

- Wallet full of NFC tags—what happens?
- Don't want to “jam” the communication signal with all the tags talking at the same time
- NFC uses TDMA and FDMA
  - Discuss the theory